

IxNetwork — Software Defined Network (SDN) Test Solution

Validate Diverse SDN Technologies to Meet Your Business Needs

Problem: SDN Revolutionizing How Networking is Done

SDN has emerged as a new networking paradigm that transforms the existing closed network into open and programmable components of a highly scalable cloud infrastructure. It redefines how networks are built to better support business agility. This paradigm shift requires extensive testing and validation to ensure that it can deliver the benefits promised by SDN. With multiple emerging and competing technologies addressing different deployment scenarios, it is critical for equipment makers, service providers, and enterprises to have the ability to quickly and thoroughly qualify products and services before deployment.

Solution: A Comprehensive Test Solution for Dynamic and Diverse SDN Networks

The IxNetwork SDN test solution delivers feature sets covering various SDN technology approaches, including green-field OpenFlow deployment, carrier network SDN technology, data center virtualization overlay, as well as overall orchestration and management. The IxNetwork SDN solution emulates carrier-scale, multi-service, complex SDN networks to stress Device Under Test (DUT) or the end-to-end networks under dynamic conditions with flexibility and advanced operation to test every aspect of user scenarios.

Highlights

- Qualify SDN deployment scenarios and use cases with realistic networks and device emulation
- Ensure smooth deployment by testing with carrier class network emulation, dynamic service modeling at internet scale, and rapid isolation of service violations
- Accelerate time to market delivery and minimize financial risks of network migration with effective tool to validate cutting edge technology
- Ensure network design meets business demand by stressing hyper scale data center networks with peak load
- Automate end to end with REST and other APIs for continuous validation before rolling out new product and services

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Key Features

- OpenFlow controller and switch emulation supports OpenFlow version 1.0 and 1.3.1 for conformance, functional, scale and performance testing
- Segment Routing (SR) extension for OSPF, ISIS and BGP emulates realistic network topology to stress DUT SR implementation and validate data plane forwarding based on the instructions in the packet itself
- Segment Routing IPv6 (SRv6) emulation validates SRv6 underlay, global IPv4/IPv6 services and L3VPN/EVPN application overlay for network programmability
- SRv6 OAM emulation validates ping, traceroute, S-BFD and BFD functionalities over SRv6/G-SRv6 data-plane
- PCEP and BGP-LS emulation validates Traffic Engineering Database (TED) distribution and existing Link State Database (LSDB) synchronization, programmability of optimized traffic engineering path based on network resource and constraints, as well as data forwarding performance along the TE path.
- BGP SR TE Policy emulation validates SR TE policy advertisement and capability to direct traffic into Explicit Unequal Cost Multi-Path (UCMP)
- Flexible Algorithm (Flex-Algo) emulation for ISIS and OSPFv2 validates IGP constraint-based path computation for SR MPLS path. Flex-Algo emulation for ISIS also validates constraint-based path computation for SRv6 path
- VXLAN and GENEVE emulation stress-tests the ability of physical or virtual VTEP handling large number of remote VTEPs and VMs, as well as supporting VM mobility within or across data center
- EVPN with MPLS or VXLAN data plane emulates large number of PE or VTEPs to qualify virtualization overlay, L2/L3 services, advanced multi-homing capability of Data Center devices and Data Center Network
- OVSDb client and server emulation supports HW_VTEP schema to validate overlay network provision in Software Defined Data Center
- NETCONF client and server emulation executes command sets agnostic to Yang model to test NETCONF/YANG execution, as well as stress router/switch management plane and controller NETCONF session scale
- BIER emulation validates control plane operation of ISIS/OSPF underlay and MVPN service overlay operation, multicast traffic forwarding and replication, as well as scale/performance of BIER network
- In-Band Telemetry packet templates help to generate traffic mix to validate INT data insertion and measure the forwarding performance with telemetry load
- eCPRI message generation validates 5G fronthaul transport network with eCPRI messages along with other data traffic to ensure QoS and ultra-low latency
- gRIBI client emulation validates RIB entry injection in target routing devices over gRPC channels
- TWAMP Light Sender and Receiver emulation to validate measurement of both one-way and two-way performance metrics like delay, delay variation, and packet loss
- SRv6 Path Tracing Source emulation to test recording of packet path information over SRv6 network

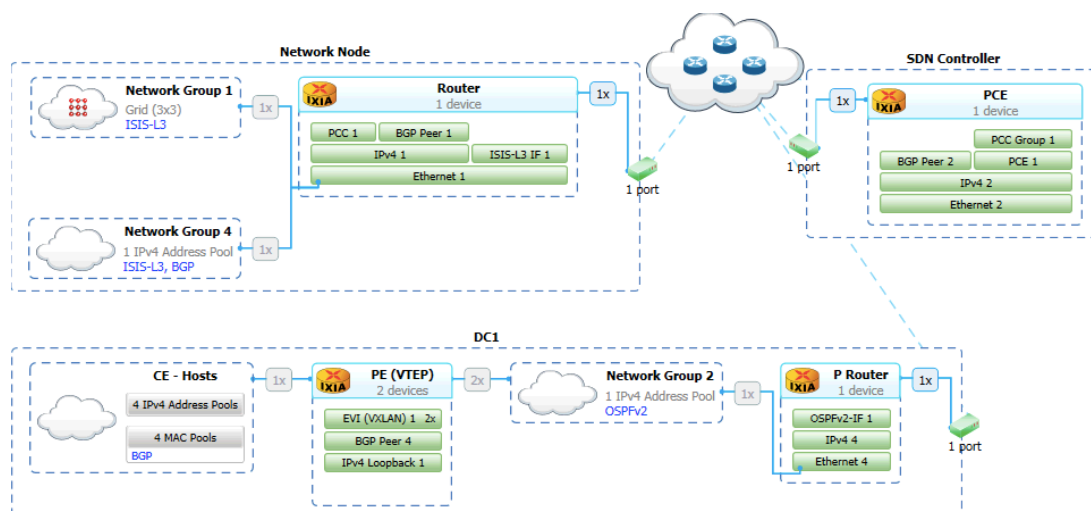


Figure 1. IxNetwork test solution for software-defined core network and data center network

Specifications

ISIS segment routing

Standards	• RFC 8667 IS-IS Extensions for Segment Routing • RFC 9352 IS-IS Extensions to Support Segment Routing over the IPv6 Data Plane • RFC 7794 IS-IS Prefix Attributes for Extended IPv4 and IPv6 Reachability • RFC 8570 IS-IS Traffic Engineering (TE) Metric Extensions • RFC 7308 Extended Administrative Groups in MPLS Traffic Engineering (MPLS-TE) • draft-ietf-isis-te-app-19 IS-IS TE Attributes per application • RFC 6119 IPv6 Traffic Engineering in IS-IS
Prefix/Node TLV	• TLV — 135 (IPv4) • TLV — 236 (IPv6) • TLV — 237 (MT-IPv6)
Neighbor/Adjacency TLV	• TLV — 22 (extended IS reachability) • TLV — 222 (MT IS TLV) • TLV — 23 (neighbor attribute) • TLV — 223 (MT neighbor attribute)
Sub – TLVs	• SR-Capabilities • SR-Algorithm • Prefix SID • Adjacency SID • LAN-Adj-SID • SID/Label • SRLB

ISIS segment routing

- SRMS Preference
- SID/Label Binding
- Prefix Attribute Flags (default values only, no user input)

OSPFv2 segment routing

Standards	• RFC 8665 OSPF Extensions for Segment Routing • RFC 7684 OSPFv2 Prefix/Link Attribute Advertisement • draft-ietf-lsr-ospf-prefix-originator-00 • RFC 7308 Extended Administrative Groups in MPLS Traffic Engineering (MPLS-TE)
OSPFv2 Router Information Opaque LSA	• SR-Algorithm TLV • SID/Label Range TLV • SRLB • SRMS Preference
OSPFv2 Extended Prefix Opaque LSA	• OSPFv2 Extended Prefix TLV • OSPFv2 Extended Prefix Range TLV • Prefix SID Sub-TLV • Prefix Source Router-ID Sub-TLV
OSPFv2 Extended Link Opaque LSA	• OSPFv2 Extended Link TLV • Adj-SID Sub-TLV • LAN Adj-SID Sub-TLV

OSPFv3 segment routing

Standards	• RFC 8666 OSPFv3 Extensions for Segment Routing
OSPFv3 Router Information Opaque LSA	• SR-Algorithm TLV • SID/Label Range TLV
OSPFv3 Extended Router LSA	• Router Link TLV • Adj-SID Sub-TLV • LAN Adj-SID/Label Sub-TLV
OSPFv3 LSAs and TLV/Sub-TLVs:	LSAs • E-Inter-Area-Prefix-LSA • E-Inter-Area-Router-LSA • E-AS-External-LSA • E-Type-7-LSA • E-Intra-Area-Prefix-LSA

OSPFv3 segment routing

TLV/Sub-TLVs

- Inter-Area-Prefix TLV
- Inter-Area-Router TLV
- External Prefix TLV
- Intra-Area-Prefix TLV
- SID/Label Sub-TLV

BGP segment routing

Standards	• RFC 8669 Segment Routing Prefix Segment Identifier Extensions for BGP • draft-ietf-idr-bgp-prefix-sid-03 • RFC3107-Carrying Label Information in BGP-4
BGP-Prefix-SID Attribute	• Label-Index-TLV • Originator SRGB TLV

BGP link state emulation

Standards	• RFC 7752 — North-Bound Distribution of Link-State and Traffic Engineering (TE) Information Using BGP • draft-ietf-idr-bgp-ls-segment-routing-ext-16 • draft-ietf-idr-bgpls-segment-routing-epe-19 • draft-ietf-idr-bgpls-srv6-ext-08 • draft-ietf-idr-bgp-ls-segment-routing-msd-05 • draft-ietf-idr-te-lsp-distribution-17 • RFC 8571 — Link State (BGP-LS) Advertisement of IGP Traffic Engineering Performance Metric Extensions • RFC 9104 — Distribution of Traffic Engineering Extended Administrative Groups Using the Border Gateway Protocol - Link State (BGP-LS) • RFC 9351 – BGP-LS Extensions for Flexible Algorithm Advertisement
Capability	• Non-VPN: AFI 16388 / SAFI 71
Link-State NLRI	• Node • Link • IPv4 Prefix • IPv6 Prefix • SRv6 SID
Node Descriptors TLV	• Local Node Descriptors • Remote Node descriptors
Node Descriptor Sub-TLV	• AS • BGP-LS ID • OSPF Area-ID • IGP Router-ID

BGP link state emulation

Multi-Topology ID TLV (ISIS only)	• MT ID 0 (IPv4 Unicast) • MT ID 2 (IPv6 Unicast)
Link Descriptors TLV	• IPv4 interface address • IPv4 neighbor address • IPv6 interface address • IPv6 neighbor address
Prefix Descriptors TLV	• OSPF Route Type • IP Reachability Information
Node Attribute TLV	• Multi-Topology ID (ISIS only) • Node Flag Bits • Node Name (ISIS only) • ISIS Area ID • IPv4 Router ID of Local Node • SID/Label Binding • SR Capabilities • SR Algorithm • SRLB • SRMS Preference
Link Attribute TLV	• Local IPv4/IPv6 Router ID • Remote IPv4/IPv6 Router ID • Administrative group • Maximum link bandwidth • Max reservable link bandwidth • Unreserved bandwidth • TE Default Metric • IGP Metric • Adjacency Segment Identifier • LAN Adjacency Segment Identifier
Prefix Attribute TLV	• IGP Flag • Prefix Metric • Prefix SID • Range • Prefix Attribute Flags • Source Router-ID
Flexible Algorithm Definition TLV	• Flexible Algorithm Exclude-Any Affinity • Flexible Algorithm Include-Any Affinity • Flexible Algorithm Include-All Affinity • Flexible Algorithm Definition Flags
SRv6 SID NLRI	• SRv6 SID Information TLV
SRv6 TLVs	• SRv6 Capabilities TLV • SRv6 Node MSDs ◦ Maximum Segments Left

BGP link state emulation

- Maximum End Pop
- Maximum T.Insert
- Maximum T.Encaps
- Maximum End D
- SRv6 End.X SID TLV

BGP link state emulation

- SRv6 LAN End.X SID TLV
- SRv6 Link MSDs [same as Node MSDs]
- SRv6 Locator TLV
- SRv6 BGP Peer Node SID TLV
- SRv6 Endpoint Behavior TLV
- SRv6 SID Structure TLV

TE Policies (Rx)

- NLRI - TE Policy NLRI (Type 5)
- Protocol-ID: Segment Routing (Type 9)
- Protocol Origin: BGP SR Policy (Code Point 2)

PCEP emulation

Standards

- RFC 4655 — A path Computation Element (PCE)-Based Architecture
- RFC 4657 — Path Computation Element (PCE) Communication Protocol Generic Requirements
- RFC 5440 — Path Computation Element (PCE) Communication Protocol (PCEP)
- RFC5521 — Extensions to the Path Computation Element Communication Protocol (PCEP) for Route Exclusions
- RFC 8231 — PCEP Extensions for Stateful PCE
- RFC 8281 — PCEP Extensions for PCE-initiated LSP Setup in a Stateful PCE Model
- RFC 8408 — Conveying Path Setup Type in PCE Communication Protocol (PCEP) Messages
- RFC8664 — PCEP Extensions for Segment Routing
- draft-ietf-pce-lsp-setup-type-03
- RFC 8697 – PCEP Extensions for Establishing Relationships between Sets of LSPs
- draft-ietf-pce-stateful-path-protection-01
- draft-ietf-pce-binding-label-sid-16
- draft-ietf-pce-segment-routing-ipv6-14
- draft-ietf-pce-segment-routing-policy-cp-07

PCEP Capabilities

- Stateful PCE
- LSP Update
- LSP Instantiation
- SR PCE
- SRv6 PCE

PCEP - Stateful PCE

Messages

PCEP emulation

- Open, Keepalive, PCReq, PCRep, PCRpt, PCUpd, Error, Close

Objects

- RP
 - SRP
 - LSP
-

PCEP emulation

Standards

- END POINT (IPv4/IPv6)
- ERO
- RRO
- IRO
- XRO
- BANDWIDTH
- LSPA
- METRIC
- NO-PATH
- PCEP-ERROR
- CLOSE
- ASSOCIATION (IPv4/IPv6)

TLVs

- Stateful-PCE-Capability
 - Path Setup Type
 - IPv4-LSP-Identifiers
 - IPv6-LSP-Identifiers
 - Symbolic Path Name
 - Speaker Entity Identifier
-

PCEP - PCE initiated LSP (Add-on to Stateful PCE)

Messages

- PCInitiate

Objects

- SRP (R flag)
- LSP (C flag)
- End-Points
- ERO
- XRO
- ASSOCIATION

TLVs

- Symbolic-Path-Name TLV
 - Path Setup Type TLV
 - TE-PATH-Binding TLV
-

PCEP emulation

PCEP - Segment Routing

TLV

- SR PCE Capability TLV (for SR-TE Path)
- TE-PATH-Binding TLV
- Path Setup Type TLV

Object/Sub-Object

- SR-ERO
 - SID

PCEP emulation

- NAI
 - IPv4 Node ID
 - IPv6 Node ID
 - IPv4 Adjacency ID
 - IPv6 Adjacency with global IPv6 addresses
 - Unnumbered Adjacency with IPv4 Node IDs
 - IPv6 adjacency with link-local IPv6 addresses

PCEP – Segment Routing v6

- PATH-SETUP-TYPE-CAPABILITY
 - Type SRv6-PCE-CAPABILITY (27)
 - MSD-Types
- PCEP Path Setup Type for Traffic Engineering path setup using SRv6 (PST = 3)
- ERO/RRO Sub-Objects
 - SRv6-ERO under EXPLICIT_ROUTE Object
 - SRv6-RRO under ROUTE_RECORD Object
 - SRv6 SID
 - SID Structure
 - SRv6 NAI Types
 - IPv6 Node ID
 - IPv6 Global Adjacency
 - IPv6 adjacency with link-local IPv6 addresses

VXLAN

Standards

RFC 7348 — Virtual eXtensible Local Area Network (VXLAN): A Framework for Overlaying Virtualized Layer 2 Networks over Layer 3 Network

Protocol Option

- Number of VTEP
- Number of VNIs/VTEP (default 1)
- UDP Port (default 8472)
- VNI
- IPv4 Multicast Address

Host Protocol support over VXLAN VTEPs

- Ethernet
- ARP
- IPv4

VXLAN

	• ICMP/Ping • DHCP • IGMP • MLD
VTEP Discovery (Discovery Domain)	• Multicast (IGMP, PIM) • Unicast (Static VTEP configuration)
Routing Protocol Support to Advertise VTEP Reachability	• OSPF • BGP

OVSDB

Standards	• RFC 7047 — The Open vSwitch Database Management Protocol • hardware_vtep schema: http://openvswitch.org/docs/vtep.5.pdf
Protocol option	OVSDB Server • Schema — HW VTEP • Connection Type — TCP or TLS • TCP Port • Certificate Directory • Private Key File • Certificate File • CA Certificate File • Manager Count Managers • Active • IPv4 Address • TCP Port OVSDB Controller • Schema — HW VTEP • Connection Type — TCP or TLS • TCP Port • Certificate Directory • Private Key File • Certificate File • Verify Peer Certificate • CA Certificate File Cluster Data • Attach at Start • Logical Switch Name • VNI • Physical_Switch name • Physical_Port name • VLAN ID

EVPN MPLS and EVPN VXLAN

Standards	• RFC 7432 — EVPN • RFC 7623 — PBB-EVPN • draft-ietf-bess-evpn-overlay-01 • RFC 9135 • draft-ietf-bess-evpn-prefix-advertisement-04 • RFC5512 • draft-ietf-bess-evpn-vpws-07
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EVPN MPLS and EVPN VXLAN

	• draft-sajassi-bess-evpn-vpws-fxc-01 • draft-sharma-multi-site-evpn-03 • draft-sajassi-bess-evpn-mvpn-seamless-interop-03 • draft-ietf-bess-evpn-igmp-mld-proxy-05 • draft-ietf-bess-evpn-irb-mcast-04 • draft-ietf-bess-evpn-bum-procedure-updates-08 • RFC 8317 – EVPN E-Tree
Capability	• AFI = 25 (L2VPN) • SAFI 70 (EVPN)
Route type	• Type 1 — Ethernet Auto-Discovery (A-D) Route • Type 2 — MAC/IP Advertisement Route • Type 3 — Inclusive Multicast Ethernet Tag Route • Type 4 — Ethernet Segment Route • Type 5 — IP Prefix Route • Type 6 — Selective Multicast Ethernet Tag Route (EVPN VXLAN only) • Type 7 — Multicast Join Synch Route (EVPN VXLAN only) • Type 8 — Multicast Leave Synch Route (EVPN VXLAN only) • Type 10 — S-PMSI A-D Route (EVPN VXLAN only)
Extended community	• ESI Label Extended Community • ES Import Route Target • MAC Mobility Extended Community • Default Gateway Extended Community • BGP encapsulation Extended Community • Router MAC Extended Community • Layer 2 attributes Extended Community • Multicast Flags Extended Community • EVI-RT Extended Community • E-Tree Extended Community
Multi-homing functions	• All-Active Ethernet Segment • Single-Active Ethernet Segment • Fast Convergence

EVPN MPLS and EVPN VXLAN

	• Split Horizon • Aliasing and Back-Up Path • Designated Forwarder Election
L2 BUM Traffic Forwarding	• Ingress Replication • RSVP-TE P2MP (MPLS data plane only) • mLDP P2MP (MPLS data plane only) • PIM-SM/SSM/BIDIR (VXLAN data plane only)
L3 Multicast Forwarding (Tenant Routed Multicast)	• Ingress Replication (I-PMSI only) • PIM-SM (I-PMSI and S-PMSI) • PIM-SSM (I-PMSI and S-PMSI)
L3 Multicast Forwarding	• PIM-SM (using EVPN S-PMSI A-D route) • PIM-SSM (using EVPN S-PMSI A-D route) • Ingress Replication (using EVPN SMET Route)

BGP segment routing traffic engineering policy

Standards	• draft-ietf-idr-sr-policy-safi-13 • draft-ietf-idr-bgp-sr-segtypes-ext-08 • draft-ietf-idr-tunnel-encaps-04 • RFC 5512 — The BGP Encapsulation Subsequent Address Family Identifier (SAFI) and the BGP Tunnel Encapsulation Attribute
Capability	• AFI 1 / SAFI 73 (IPv4 SR TE Policy) • AFI 2 / SAFI 73 (IPv6 SR TE Policy) • Graceful Restart
SR TE Policy Sub-TLVs	• Remote Endpoint • Color • Preference • Binding SID (including flags S-flag and I-Flag) • Segment List • Explicit NULL Label Policy • Policy Priority • Policy Name • SRv6 Binding SID • Policy Candidate Path Name
Extended community for actions	• Extended Color Community
Segment Sub-TLV Type	• Type 1: Type A MPLS SID sub-TLV • Type 2: Deprecated Type B (SRv6 SID sub-TLV) • Type 3: Type C IPv4 Node and SID sub-TLV • Type 4: Type D IPv6 Node and SID for SR-MPLS sub-TLV • Type 5: Type E IPv4 Node, index, and SID sub-TLV • Type 6: Type F IPv4 Local/Remote addresses and SID sub-TLV

BGP segment routing traffic engineering policy

	• Type 7: Type G IPv6 Node, index for remote and local pair, and SID for SR-MPLS sub-TLV • Type 8: Type H IPv6 Local/Remote addresses and SID sub-TLV • Type 9: Weight sub-TLV • Type 13: Type B SRv6 SID sub-TLV • Type 14: Type I IPv6 Node and SID for SRv6 sub-TLV • Type 15: Type J IPv6 Node, index for remote and local pair, and SID for SRv6 sub-TLV • Type 16: Type K IPv6 Local/Remote addresses and SID for SRv6 sub-TLV
Other fields of segment Sub-TLVs	• SR Algorithm • SRv6 SID Endpoint Behavior and Structure sub • Segment Flags (V, A, S, B)

Segment routing v6

Standards	• draft-ietf-6man-segment-routing-header-11 • draft-filsfils-spring-srv6-network-programming-04 • RFC 7794 IS-IS Prefix Attributes for Extended IPv4 and IPv6 Reachability • RFC 9352 IS-IS Extensions to Support Segment Routing over the IPv6 Data Plane • draft-ietf-lsr-ospfv3-srv6-extensions-02 • RFC 6119 IPv6 Traffic Engineering in IS-IS • draft-dawra-idr-srv6-vpn-04 • draft-ietf-bess-srv6-services-15 • RFC 5549 Advertising IPv4 Network Layer Reachability Information with an IPv6 Next Hop • draft-ietf-idr-bgpls-srv6-ext-00 • draft-ietf-idr-bgp-ls-segment-routing-msd-05 • draft-ietf-pce-segment-routing-ipv6-14 • draft-ietf-6man-spring-srv6-oam-11 • RFC 7880: Seamless Bidirectional Forwarding Detection (S-BFD) • draft-filsfils-spring-net-pgm-extension-srv6-usid-13
ISIS SRv6 capability	• SRv6 Capability TLV • Maximum SL sub-sub-TLV (1) • Maximum End Pop SRH sub-sub-TLV (2) • Maximum T.Insert SRH sub-sub-TLV (3) • Maximum T.Encap SRH sub-sub-TLV (4) • Maximum End D SRH sub-sub-TLV (5)
ISIS SRv6 TLV	• SRv6 Node SID • SRv6 Adjacency SID • SRv6 LAN Adjacency SID • SRv6 SID Structure
SRv6 compression	• Micro SID • G-SRv6

Segment routing v6

OSPFv3 Router Information LSA	• SRv6 Capabilities TLV (Type 20) • Node MSDs: ◦ Maximum Segment Left ◦ Maximum End Pop ◦ Maximum H.Encaps ◦ Maximum End D
OSPFv3 LSAs for SRv6	• SRv6 Locator LSA (Type 42) ◦ SRv6 Locator TLV ◦ SRv6 End SIDs • Link MSDs as sub-TLVs of E-Router-LSA: ◦ Maximum Segment Left ◦ Maximum End Pop ◦ Maximum H.Encaps • P2P and broadcast adjacencies in E-Router-Link TLV ◦ SRv6 End.X Sub-TLV ◦ SRv6 LAN End.X SID sub-TLV • SRv6 SID Structure Sub-TLV ◦ End SIDs and End.X SIDs
Endpoint function	• End, End.X, End.T (PSP, USP, PSP & USP, no PSP/USP) • End.DX6, End.DT6 • End.OTP • End, END.X with NEXT-ONLY-CSID • End, End.X (PSP, USP, PSP & USP, USD, PSP & USD, USP & USD, PSP & USP & USD, None) • End.DX6, End.DX4, End.DT6, End.DT4, End.DT46 with NEXT-CSID • End.DX2, End.DX2V, End.DT2U, End.DT2M with NEXT-CSID • End, End.X, End.T with COC, PSP & COC, PSP & USP & COC, PSP & USD & COC, PSP & USP & USD & COC) • Custom (user defined value)
BGP L3VPN over ISIS SRv6 underlay	• SRv6-VPN SID TLV • SRv6 SID Structure
BGP EVPN over ISIS SRv6 underlay	• VPWS • VPLS Type 1 Route • VPLS Type 2 Route • VPLS Type 3 Route • VPLS Type 5 Route
BGP Global services over ISIS SRv6 underlay	• IPv4 over SRv6 core • IPv6 over SRv6 core
BGP-LS with ISIS	SRv6 SID NLRI • SRv6 SID Information TLV SRv6 TLVs • SRv6 Capabilities TLV • SRv6 Node MSDs ◦ Maximum Segments Left

Segment routing v6

	◦ Maximum End Pop ◦ Maximum T.Insert ◦ Maximum T.Encaps ◦ Maximum End D • SRv6 End.X SID TLV • SRv6 LAN End.X SID TLV • SRv6 Link MSDs [same as Node MSDs] • SRv6 Locator TLV • SRv6 Endpoint Behavior TLV • SRv6 BGP Peer Node SID TLV • SRv6 SID Structure TLV
SRv6/GSRv6 OAM	• Ping • Traceroute • S-BFD • BFD

ISIS Flexible Algorithm (Flex-Algo)

Standards	• draft-ietf-isr-flex-algo-10
ISIS router capability TLV (TLV 242)	• Flex-Algo Definition Sub-TLV ◦ Calculation type ◦ Metric type ◦ Priority • FAD TLV ◦ FA Exclude AG Sub-TLV ◦ FA Include-Any AG Sub-TLV ◦ FA Include-All AG Sub-TLV ◦ FAD Flags Sub-TLV • FAPM TLV

OSPFv2 Flexible Algorithm (Flex-Algo)

Standards	• draft-ietf-isr-flex-algo-13
ISIS router capability TLV (TLV 242)	• Flex-Algo Definition Sub-TLV ◦ Calculation type ◦ Metric type ◦ Priority • FAD TLV ◦ FA Exclude AG Sub-TLV ◦ FA Include-Any AG Sub-TLV ◦ FA Include-All AG Sub-TLV ◦ FAD Flags Sub-TLV • FAPM TLV

BGP flow specification

Standards	• RFC 8955 - Dissemination of Flow Specification Rules • RFC 8956 - Dissemination of Flow Specification • Rules for IPv6 • draft-ietf-idr-flowspec-redirect-ip-02 • RFC 8092 — BGP Large Communities Attribute • draft-jiang-idr-ts-flowspec-srv6-policy-07
Capability	• AFI 1 / SAFI 133 (IPv4 Unicast Flowspec) • AFI 2 / SAFI 133 (IPv6 Unicast Flowspec)
Match components type (IPv4)	• Type 1 — Destination Prefix • Type 2 — Source Prefix • Type 3 — IP Protocol • Type 4 — Port • Type 5 — Destination port • Type 6 — Source port • Type 7 — ICMP • Type 8 — ICMP code • Type 9 — TCP flags • Type 10 — Packet length • Type 11 — DSCP (Diffserv Code Point) • Type 12 — Fragment
Match components changes (IPv6)	• Type 1 — Destination IPv6 Prefix • Type 2 — Source IPv6 Prefix • Type 3 — Next Header IP • Type 12 — Fragment • Type 13 — Flow Label
Extended community for actions	• Traffic-Rate-Bytes (0x8006) • Traffic-Rate-Packets (0x800c) • Traffic-Action (0x8007) • Redirects: ◦ RT AS-2byte (0x8008) ◦ RT IPv4 (0x8108) ◦ RT AS-4byte (0x8208) ◦ IPv4 Next-Hop (0x010c) ◦ IPv6-Address-Specific Extended Community - IPv6 Next-Hop (0x000c) - RT Redirect IPv6 (0x000d) • Traffic Marking (0x8009)

Multicast using Bit Index Explicit Replication (BIER)

Standards	• RFC 8279 BIER architecture • RFC 8296 BIER MPLS Encapsulation • RFC 8401 BIER support via IS-IS • draft-ietf-bier-mvpn-11.txt • draft-ietf-bier-ospf-bier-extensions-18
ISIS	• BIER Info sub-TLV • BIER MPLS Encapsulation sub-sub-TLV
OSPF	• BIER sub-TLV • BIER MPLS Encapsulation sub-sub-TLV
mVPN	• PMSI Tunnel Attribute for BIER

Network Configuration Protocol (NETCONF)

Standards	• RFC 6241 Network Configuration Protocol • RFC 6242 Using the NETCONF Protocol over Secure Shell (SSH)
Capability	• base1.0/1.1 • Writeable-running • Candidate configuration • Confirmed commit • Rollback-on-Error • Validate • Distinct startup • URL • XPath • Notification • Interleave • Configurable yang modules • Configurable RPC responses
Operation	• get • get-config • edit-config • copy-config • delete-config • lock • unlock • close-session • kill-session • event • get-schema
SSH authentication	• No authentication • Username/password

Network Configuration Protocol (NETCONF)

- Key based

Seamless BFD

Standards	• RFC 7880 • RFC 7881 • RFC 7882
Supported protocols	• ISIS SR (Keysight is egress of SR LSP) • Any MPLS protocols (Keysight is ingress of MPLS LSP)
Supported mode	• IPv4 MPLS • SRv6

OpenFlow

Standards	• OpenFlow v 1.0 • OpenFlow v 1.3.1 • RFC 4346/RFC 5246 — TLS 1.1/1.2
Message type	• TCP/TLS (OF-Channel) • Hello • Feature Request/Reply • Echo Request/Reply/Pause/Resume • Vendor/Experimenter Message • Barrier • Flow Modification (Add, Delete, Modify) • Switch Config
Flow	OpenFlow 1.0 Controller Emulation • Full 12 tuple Match Support • All Actions Including Output (Port, All, Controller, In_Port, Local, Normal, Flood) and Vendor (0xffff) OpenFlow 1.3.1 Controller Emulation (Specific) • Flow Table with Full OXM Extensible Match Support, Including IPv4/v6 Support, IPv6 Extension Header, Multiple Levels of VLAN Tagging, MPLS Support, Tunnel ID Metadata, PBB Tagging • Instructions • OXM Extensible Set-Field Actions • Experimenter
Stats request/reply	OpenFlow Controller Emulation • Flow Stats (Individual/Aggregated) • Port Stats • Vendor/Experimenter Stat • Description Stat • Table Stat • Queue Config/Stat

OpenFlow

- Vendor Stats
- Port Features

OpenFlow

- Group Stat
- Meter Stat

Learned info

OpenFlow Controller Emulation

- Feature Reply
- Port Status
- Error Message
- Switch Capabilities
- Action Supported
- Flow Stat
- Port Stat
- Vendor Stat
- Description Stat
- Table Stat
- Queue Stat
- Queue Config Stat
- Topology Learned Info (via LLDP)

OpenFlow Switch Emulation

- OF-Channel Learned Info
- Flow Learned Info
- Host Topology Information

Test composer OpenFlow events

- OpenFlow 1.0 Controller Emulation
- Pause/Resume Request/Reply
- Send Request
- Stat Request
- Barrier
- Flow
- Config
- Description
- Feature
- Queue
- Table
- Vendor, Vendor Message
- LLDP — Packet out
- Flow Add, Delete, Modify
- OpenFlow 1.3.1 Controller Emulation
- Description stat
- Port stat
- Table stat

OpenFlow

- Experimenter message
- Queue config
- Queue Stat

OpenFlow

Benchmarking QT (optional)

OpenFlow Benchmarking QuickTest

- OpenFlow Switch Flow Table Capacity Test
- L2/L3 Address Learning Rate of OpenFlow Network
- OpenFlow Switch Flow Failover Performance
- RFC2544 — Benchmarking Methodology for Network Interconnect Devices
- RFC2889 — Benchmarking Methodology for LAN Switching Devices
- RFC3918 — Methodology for IP Multicast Benchmarking

gRIBI

Standards

- gRPC reference: <https://github.com/grpc> (As on May 10, 2021)
- gRIBI reference: <https://github.com/openconfig/gribi> (As on Apr 23, 2021)

Device role

- gRIBI Client

AFT types

- Next-Hop
- Next-Hop-Group
- IPv4

eCPRI

Standards

- eCPRI Specification V1.1 (2018)

Device role

- RE and Radio Channels/Users
- REC

Transport

- eCPRI over Ethernet
- eCPRI over UDP

Message types

- IQ Data
- Bit Sequence
- Generic Data Transfer
- Real-Time Control Data
- Remote Memory Access
- One-way Delay Measurement
- Remote Reset
- Event Indication

ORAN Fronthaul

Standards	• ORAN WG4 CUS plane specification
Transport	• ORAN CU-plane over eCPRI over Ethernet • ORAN CU-plane over eCPRI over UDP over IPv4 • ORAN CU-plane over eCPRI over UDP over IPv6
Device roles	• O-DU • O-RU
Configuration parameters and functionalities	• Number of carriers • Carrier Bandwidth • Numerology • PRB Count • IQ Compression method • Wizard support for creating realistic ORAN Fronthaul traffic between simulated O-DU and O-RU

nFAPI

Standards	• SCF225 5G nFAPI specification
Message type	• P7
Functionalities	• P7 message generation with capability to inject error such as drop sequence, reorder sequence • P7 message generation with more than one segment, reordering of segments, intermittent dropping of segments

TWAMP light

Standards	• RFC 5357 Appendix I - Two-Way Active Measurement Protocol Light • RFC 8762 - Simple Two-Way Active Measurement Protocol
Transport	• IPv4 • IPv6
Device roles	• Session-Sender • Session-Reflector
Protocol functionalities	• Stateless • Configurable UDP Port

In-Band Network Telemetry (INT)

Standards	• In-band Network Telemetry Dataplane Specification
Templates	• Gevene With INT • INT Metadata • INT Shim Header

In-Band Network Telemetry (INT)

- INT Probe Marker
- VXLAN GPE
- INTv2.1 Shim Header for TCP/UDP
- INTv2.1 Shim Header for VxLAN GPE
- INTv2.1 MD Metadata
- INTv2.1 MX Metadata
- Geneve with INTv2.1 MD
- Geneve with INTv2.1 MX

Path tracing

Standards	• draft-filsfils-ippm-path-tracing-00 : Path Tracing in SRv6 networks
Device role	• PT Source
PT headers	• IPv6 Hop-by-Hop Option for Path Tracing (HbH-PT) - MCDs • IPv6 Destination Option for Path Tracing (DOH-PT) - Session ID - Interface ID - Interface Load - Timestamp

Platform Options

Visit www.keysight.com for more information on IxNetwork platform options.

Virtual platform	• IxNetwork Virtual Edition (VE)
Chassis	• XGS12-HSL/SDL/SD Chassis • XGS2-HSL/SDL/SD Chassis
Fixed chassis	• AresONE-M 800GE QSFP-DD800 • AresONE-M 800GE OSPF800 • AresONE-M 800GE Dual Interface Model • AresONE-S 400G QSFP-DD • AresONE 400G QSFP-DD • AresONE 400G OSPF • AresONE 400G High Performance QSFP-DD 400/200/100/50GE • NOVUS ONE PLUS 3- and 5-Speed 10GE/5GE/2.5GE/1GE/100M
Appliances	• NOVUS ONE 10GE/1GE/100M
Load modules	• K400 QSFP-DD 400/200/100/50GE • K400 CFP8 400GE • NOVUS High Density QSPF28 100/50/40/25/10GE • NOVUS High Density SFP28/QSPF28 100/50/25/10GE

Visit www.keysight.com for more information on IxNetwork platform options.

- NOVUS 3-Speed 10GE/1GE/100M
 - NOVUS 5-Speed 10GE/5GE/2.5GE/1GE/100M
 - Xcellon-Multis QSFP28 100/50/25GE
 - Xcellon-Multis CFP4 100GE
 - Xcellon-Multis CXP 100/40/10GE
 - Xcellon-Multis QSFP 40/10GE
 - Xcellon-Lava CFP 100/40GE
 - Xcellon-Flex QSFP/SFP+ 40/10GE
-

IxNetwork Technology Solutions

Visit www.keysight.com for more information on IxNetwork technology solutions.

- IxNetwork Overview — L2/3 Network Infrastructure Performance Testing
 - IxNetwork Software Defined Networking (SDN) Test Solution
 - IxNetwork Routing and Switching Test Solution
 - IxNetwork MPLS Test Solution
 - IxNetwork Industrial Ethernet Test Solution
 - IxNetwork Data Center Ethernet Test Solution
 - IxNetwork Broadband and Authentication Test Solution
 - IxNetwork MACsec Test Solution
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Ordering Information

OpenFlow emulation

930-2104

IxNetwork, Optional Software, OpenFlow Controller Emulation; REQUIRES: 930-2056 IxNetwork Base PLUS OR 930-2076 IxNetwork Base PREMIUM

930-2105

IxNetwork, Optional Software, OpenFlow Switch Emulation; REQUIRES: 930-2056 IxNetwork Base PLUS OR 930-2076 IxNetwork Base PREMIUM

930-2107

IxNetwork, Optional Software Bundle, OpenFlow Protocol Bundle; INCLUDES 930-2104 OpenFlow Controller Emulation; 930-2105 OpenFlow Switch Emulation; REQUIRES: 930-2056 IxNetwork Base PLUS OR 930-2076 IxNetwork Base PREMIUM

930-2412

IxNetwork, Optional Software, OpenFlow QuickTest; OpenFlow Benchmarking test; Flow Table Capacity, Flow Learning Rate, Flow Failover Test; REQUIRES IxNetwork OpenFlow Emulation License (930-2107)

OpenFlow conformance

924-442-10PBF

IxANVL, Protocol Test Package, SDN bundle

Segment routing emulation

930-2114

IxNetwork, Optional Software, IS-IS Segment Routing Emulation; REQUIRES: 930-2056 IxNetwork Base PLUS OR 930-2076 IxNetwork Base PREMIUM; AND 930-2010 IS-IS Emulation, and 930-2011 IS-IS v6 Emulation

930-2117

IxNetwork, Optional Software, OSPFv2 Segment Routing Emulation REQUIRES 930-2008 OSPFv2 Emulation; REQUIRES pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

930-2116

IxNetwork, Optional Software, BGP Link State (BGP-LS) and BGP Segment Routing Emulation REQUIRES 930-2005 BGP4 Emulation, AND/OR 930-2007 BGP v6 Emulation; REQUIRES pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

930-2123

IxNetwork, Optional Software, IPv6 Segment Routing Emulation (930-2123); Enable Segment Routing Support for IPv6 data plane (SRv6); REQUIRES: 930-2010 IS-IS Emulation AND 930-2011 IS-IS Emulation with additional IPv6 support; REQUIRES: pre-existing 930-1999 IxNetwork Base License OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076); Recommend with: 930-2122 BGP SR TE Policy Emulation for SRv6 Traffic Engineering

930-2134

IxNetwork, Optional Software, OSPFv3 Segment Routing Emulation; REQUIRES: 930-2009 OSPFv3 Emulation; REQUIRES: pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

PCEP emulation

930-2118

IxNetwork, Optional Software, Path Computation Element Communication Protocol (PCEP) Emulation; REQUIRES pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076) Recommend with: 930-2114 ISIS Segment Routing, OR 930-2117 OSPFv2 Segment Routing, OR 930-2116 BGP Link State Emulation

BGP SR TE policy emulation

930-2122

IxNetwork, Optional Software, BGP SR TE Policy Emulation; REQUIRES 930-2005 BGP4 Emulation; REQUIRES pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

IGP flexible algorithm emulation

930-2133

IxNetwork, Optional Software, ISIS Flexible Algorithm Protocol Emulation; Enable ISIS Flexible Algorithm for SR MPLS or SRv6; REQUIRES: 930-2010 IS-IS Emulation, AND/OR 930-2011 IS-IS v6 Emulation; REQUIRES: 930-2114 ISIS Segment Routing for SR MPLS OR 930-2123 IPv6 Segment Routing Emulation for SRv6; REQUIRES: pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

930-2134

IxNetwork, Optional Software, OSPFv2 Flexible Algorithm Protocol Emulation (930-2136); Enable IGP Flexible Algorithm for OSPFv2 SR MPLS; REQUIRES: 930-2008 OSPFv2 Emulation, and 930-2117 OSPFv2 Segment Routing Emulation for SR MPLS; REQUIRES: pre-existing of either 930-1999 IxNetwork Base license or IxNetwork Base PLUS (930-2056), OR new purchase of IxNetwork Base PREMIUM (930-2076)

Seamless BFD

930-2130

IxNetwork, Optional Software, Seamless Bidirectional Forwarding Detection (S-BFD) Emulation; REQUIRES: 930-2010 IS-IS Emulation AND 930-2011 IS-IS Emulation with additional IPv6 support AND 930-2114 ISIS Segment Routing Emulation; REQUIRES: pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

Segment routing bundle

930-2518

IxNetwork, Optional Software Bundle, Segment Routing Bundle (930-2518); INCLUDES; IxNetwork IS-IS Segment Routing (930-2114), IxNetwork BGP Link State (BGP-LS) (930-2116), IxNetwork OSPFv2 Segment Routing (930-2117), IxNetwork Path Computation Element Communication Protocol (PCEP) (930-2118); REQUIRES BGP4 Emulation (930-2005), AND/OR BGPv6 Emulation, AND OSPFv2 Emulation (930-2008), AND ISIS Emulation (930-2010), AND/OR ISIS v6 Emulation (930-3011); REQUIRES pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

930-2519

IxNetwork, Optional Software Bundle, Segment Routing Advanced Bundle (930-2519); Enable both Segment Routing MPLS and Segment Routing IPv6; INCLUDES; IS-IS/OSPFv2/OSPFv3 Segment Routing, Segment Routing v6, BGP Link State and BGP Segment Routing, PCEP, BGP SR-TE Policy, ISIS/OSPFv2 Flexible Algorithm, S-BFD and SRv6 OAM; REQUIRES BGP4 Emulation (930-2005), AND/OR BGPv6 Emulation (930-2007), AND OSPFv2 Emulation (930-2008), AND/OR OSPFv3 Emulation (930-2009), AND ISIS Emulation (930-2010), AND/OR ISIS v6 Emulation (930-2011), AND BGP MPLS/VPN (930-2006) for L3VPN over SR/SRv6; REQUIRES pre-existing IxNetwork Base 930-1999 or 930-2056 OR new purchase of IxNetwork Base 930-2076 or 930-2212

SRv6 OAM emulation

930-2140

IxNetwork, Optional Software, SRv6 OAM Emulation; Enable SRv6 OAM Ping/Traceroute over SRv6/G-SRv6; REQUIRES: 930-2010 IS-IS Emulation AND 930-2011 IS-IS Emulation with additional IPv6 support AND 930-2123 IPv6 Segment Routing Emulation; REQUIRES: pre-existing of either 930-1999 IxNetwork Base license or IxNetwork Base PLUS (930-2056), OR new purchase of IxNetwork Base PREMIUM (930-2076); Recommend with: 930-2005 BGP4 Emulation AND 930-2006 BGP4 Emulation with additional Layer 3 MPLS/VPN & Multicast VPN Support AND 930-2007 BGP4 Emulation with additional IPv6 support for SRv6 L3VPN.

BGP FlowSpec emulation

930-2121

IxNetwork, Optional Software, BGP FlowSpec Emulation; REQUIRES 930-2005 BGP4 Emulation; REQUIRES pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

EVPN and VXLAN emulation

930-2102

IxNetwork, Optional Software, BGP Extension to support EVPN and PBB-EVPN Emulation; REQUIRES 930-2005 BGP Emulation; REQUIRES pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

930-2103

IxNetwork, Optional Software, VXLAN Emulation; Supports functional and performance testing of VXLAN Gateways; REQUIRES pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

930-2521

IxNetwork, Optional Software, EVPN and VXLAN Bundle (930-2521); INCLUDES: EVPN Emulation and VXLAN Emulation; REQUIRES BGP4 Emulation (930-2005); REQUIRES pre-existing IxNetwork Base 930-1999 or 930-2056 OR new purchase of IxNetwork Base 930-2076 or 930-2212

OVSDB emulation

930-2109

IxNetwork, Optional Software, OVSDB Emulation. Supports Open vSwitch Database Management protocol (OVSDB) for hardware VTEP schema. REQUIRES 930-2103 VXLAN Emulation, REQUIRES pre-existing 930-1999 IxNetwork Base license OR New purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

NETCONF emulation

930-2124

IxNetwork, Optional Software, Network Configuration Protocol (NETCONF) Emulation; REQUIRES pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

BIER emulation

930-2125

IxNetwork, Optional Software, Bit Index Explicit Replication (BIER) Emulation; REQUIRES 930-2005 BGP4 Emulation AND 930-2006 BGP extensions to support MPLS L3VPN/VPLS; REQUIRES 930-2010 IS-IS Emulation; REQUIRES pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

gRIBI emulation

930-2139

IxNetwork, Optional Software, gRPC Routing Information Base Interface (gRIBI) Emulation; Enable testing of Abstract Forwarding Table (AFT) receiving capability for device supporting gRIBI on top of gRPC channel as defined in OpenConfig gRIBI specification; REQUIRES: pre-existing of either 930-1999 IxNetwork Base license or IxNetwork Base PLUS (930-2056), OR new purchase of IxNetwork Base PREMIUM (930-2076)

eCPRI emulation

930-2128

IxNetwork, Optional Software, eCPRI (Common Public Radio Interface) Messages Generation; Enable generation of eCPRI messages for eRE and eREC; REQUIRES: pre-existing 930-1999 IxNetwork Base license OR new purchase of either IxNetwork Base PLUS (930-2056) or IxNetwork Base PREMIUM (930-2076)

ORAN Fronthaul traffic emulation

930-2141

IxNetwork, Optional Software, ORAN C-Plane and U-Plane Messages Generation; Enable generation of ORAN eCPRI C-Plane and U-Plane messages for O-RU and O-DU; REQUIRES: 930-2128 eCPRI (Common Public Radio Interface) Messages Generation; REQUIRES: pre-existing 930-1999 IxNetwork Base license OR new purchase of or IxNetwork Base PREMIUM (930-2076)

nFAPI

930-2143

IxNetwork, Optional Software, nFAPI message generation; Enable nFAPI P7 message generation; REQUIRES: pre-existing 930-1999 IxNetwork Base license or IxNetwork Base PLUS (930-2056), OR new purchase of or IxNetwork Base PREMIUM (930-2076)

TWAMP/TWAMP-Light emulation

930-2142

IxNetwork, Optional Software, Two-Way Active Measurement Protocol Emulation; Enable TWAMP control and test sessions, and TWAMP/TWAMP-Light Sender and Reflector emulations; REQUIRES: pre-existing 930-1999 IxNetwork Base license or IxNetwork Base PLUS (930-2056), OR new purchase of or IxNetwork Base PREMIUM (930-2076)

Path tracing emulation

930-2144

IxNetwork, Optional Software, Path Tracing Emulation; Enable Path Tracing emulation and probe generation; REQUIRES: pre-existing of either 930-1999 IxNetwork Base license or IxNetwork Base PLUS (930-2056), OR new purchase of IxNetwork Base PREMIUM (930-2076); Recommend with: 930-2123 IPv6 Segment Routing Emulation AND either 930-2010 IS-IS Emulation and 930-2011 IS-IS Emulation with additional IPv6 support or 930-2009 OSPFv3 Emulation; Recommend with 930-2070 IEEE 1588v2 (PTP) Protocol Emulation.

SDN bundle

930-2522

IxNetwork, Optional Software Bundle, Software Defined Networking (SDN) Bundle (930-2522); Enable SDN Protocol Emulations; INCLUDES; EVPN and VXLAN, IS-IS/OSPFv2/OSPFv3 Segment Routing, Segment Routing v6, BGP Link State and BGP Segment Routing, PCEP, BGP SR-TE Policy, BGP FlowSpec, Netconf, BIER, ISIS/OSPFv2 Flexible Algorithm, S-BFD and SRv6 OAM, gRIBI, TWAMP and TWAMP Light; REQUIRES BGP4 Emulation (930-2005), AND/OR BGPv6 Emulation (930-2007), AND OSPFv2 Emulation (930-2008), AND/OR OSPFv3 Emulation (930-2009), AND ISIS Emulation (930-2010), AND/OR ISIS v6 Emulation (930-2011), AND BGP MPLS/VPN (930-2006) for L3VPN over SR/SRv6 or for BIER; REQUIRES pre-existing IxNetwork Base 930-1999 or 930-2056 OR new purchase of IxNetwork Base 930-2076 or 930-2212

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